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ALTERNATIVE FINANCING SCHEMES

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ABSTRACT

Neoclassical growth models predict positive growth effects over the entire transition path following a reduction in capital or labor tax rates when lump-sum taxes (or transfers) are used to balance the government budget. This paper considers the consequences of bond-financed tax reductions that bring forth adjustments in expected future government consumption, capital tax rates, or labor tax rates. Through the resulting intertemporal distortions, current tax cuts can lower growth. The paper shows that the stronger the response of distorting fiscal policies to debt, the more favorable the growth effects of a tax cut.

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1. Introduction

In a recent paper, Mankiw and Weinzierl (forthcoming) brought modern quantitative macroeconomic analysis to bear on an important and timely policy issue: can permanent tax rate cuts stimulate economic growth and raise the tax base enough to offset some of the revenue loss? They address this issue of dynamic scoring in a conventional neoclassical growth model. A calibrated version of the model suggests that permanent reduction in capital (labor) tax rates can stimulate growth enough to offset 53 percent (17 percent) of the revenue loss. In their exercises, Mankiw and Weinzierl also find that static scoring always overstates the revenue loss of tax cuts.

In this paper, as in Mankiw and Weinzierl, *dynamic scoring* evaluates revenue effects of a tax proposal using dynamic macroeconomic models. This is distinguished from *static scoring*, which is defined as the revenue consequences of tax changes when there is no feedback from output or any other behavioral response to taxes. Although static scoring is sometimes equated to the methods employed by government agencies, such as the Congressional Joint Committee on Taxation (JCT), estimates by the JCT incorporate feedback effects from microdynamic behavior [see Joint Committee on Taxation (2005) and Auerbach (2005) for details].[1]

Mankiw and Weinzierl's provocative results hinge on the maintained assumption that lump-sum transfers are permanently cut to balance the government's budget in the face of any revenues losses. Given the vagaries of the political system, this Ricardian equivalent outcome is at best a benchmark scenario. To the extent that a reduction in one fiscal distortion is replaced by a change in some other distortion, or

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[1]The dynamic and static scoring exercises in this paper, as in Mankiw and Weinzierl, differ from the practices at the JCT, Congressional Budget Office, and Treasury. In practice, conventional revenue estimation incorporates macroeconomic forecast under existing tax laws and microeconomic dynamic adjustment under proposed tax law changes.

combination of distortions, Mankiw and Weinzierl's results are likely to change. This paper examines the robustness of their dynamic scores by considering alternative fiscal responses to permanent tax-rate cuts. We find that the assumption that transfers do all the adjusting is critical to Mankiw and Weinzierl's sanguine conclusions. Policy makers considering persistent changes in tax rates would do well to consider a range of possible fiscal responses to the resulting revenue shortfall.

Two conclusions emerge from this paper. First, a debt-financed tax cut does not always have the positive growth effects obtained in neoclassical models without debt. The growth effects of a tax cut depend crucially on which fiscal policy is adjusted. Hence, there is no guarantee that static estimates of revenue effects of tax cuts, which assume no feedback from changing tax bases, necessarily overstate the revenue loss, as Mankiw and Weinzierl (forthcoming) conclude. Second, how aggressively policy responds to debt matters for the growth effects of tax policy. Among distorting policies that ensure sustainability, a stronger response yields a smaller long-run debt-output ratio and more favorable growth consequences from a tax cut.

2. Background

Neoclassical growth models have become the main framework for studying the macroeconomic effects of fiscal policy, at least since Baxter and King (1993). When income tax rates are reduced and the government budget is balanced by lump-sum taxes or transfers, this class of models generates substantial growth, arising from higher expected returns to labor and investment.

Growth effects of tax cuts are often cited in policy debates to advocate tax cuts. While it is not uncommon for Congress to cut transfer payments when faced with revenue shortfalls, the federal government frequently resorts to borrowing instead, postponing the inevitable adjustments in spending or taxes. The federal debt-GDP ratio climbed from 57.4 percent in 2001 to 65.7 percent in 2005 [estimate from Economic Report of the President (2005)], partially due to the series of tax cuts since 2001. Demographic trends are expected to create persistent increases in Social Security, Medicare, and other transfer programs well into the 21^{st} century [Congressional Budget Office (2002)], making the maintained assumption that tax cuts are funded through transfer reductions an increasingly unlikely scenario.

Since the well-publicized assertion of the Laffer (1979) curve, research has attempted to find its theoretical underpinnings. The supply-side argument that cutting taxes generates growth is well demonstrated by endogenous growth models, where the steady state economic growth rate rises when income tax rates are lowered [King and Rebelo (1990)]. Ireland (1994) further shows that the expansionary effects of a debt-financed tax cut can be strong enough to pay off debt in the long run without offsetting fiscal policy, if the growth rate after a tax cut outpaces the growth rate of government debt. However, subsequent studies by Bruce and Turnovsky (1999) and Novales and Ruiz (2002) find that tax cuts can improve the long-run budget only for a relatively high elasticity of intertemporal substitution of consumption. While doubt remains about whether a deficit-financed tax cut can actually be self-financing, this paper considers circumstances in which such a tax cut induces future fiscal policy adjustments that maintain a sustainable budget.

We use a standard neoclassical growth model with government debt and separate distorting taxation on capital and labor income. Since the steady state growth rate of the economy is invariant to fiscal policy, debt-financed tax cuts necessarily involve adjustments in future policy to ensure that the government's intertemporal budget constraint holds. Expectations of future policies interact with labor and investment incentives from a current tax cut. Mankiw and Weinzierl (forthcoming) use the same type of model without debt to show that while capital or labor tax cuts cannot pay for themselves fully as suggested by the Laffer curve, the revenue feedback from economic growth is substantial. Because tax cuts are financed by reductions in lump-sum transfers, intertemporal interactions with future policies are eliminated from their model. This paper shows that eliminating those intertemporal margins has important consequences for the growth effects of tax cuts.[2]

Specifically, we consider permanent reductions in capital or labor tax rates. Fiscal sustainability is ensured by one of three possible policy responses: (1) lower future government transfer-output ratios, (2) lower future government spending-output ratios, or (3) future increases in other tax rates. We assume the adjustments arise intertemporally through policy rules that make fiscal variables respond to deviations of debt-GDP from its steady-state value. The simple policy rules adopted in this paper are an abstraction designed to capture the practice of fiscal policy: when the fiscal budget deteriorates, explicit fiscal actions typically are taken to improve the budget situation.

For state governments, offsetting fiscal policy is triggered relatively quickly, as most state constitutions require balancing the budget within a couple of years. No analogous statutory requirement constrains federal behavior, and offsetting policy actions can take much longer to be implemented. For example, when the debt-output ratio

[2]Baxter and King (1993) and Ludvigson (1996) also use exogenous growth models to investigate fiscal policy effects where lump-sum taxes or transfers are not allowed to be used to balance the budget. In these two papers, tax policy is the endogenous offsetting policy, which occurs contemporaneously to satisfy the government budget constraint each period.

rose rapidly in the early and mid-1980s (partly due to the large tax cuts in the Economic Recovery Act of 1981), the Gramm-Rudman-Hollings balanced-budget law was enacted in 1985 to reduce deficits. In addition, the Omnibus Budget Reconciliation Acts of 1990 and 1993, which increased individual and corporate income tax rates, were passed to reduce government debt. The quickly rising debt-GDP ratio since 2001 again has spurred calls for cutting federal deficits [Greenspan (2005a) and Greenspan (2005b)].

Aside from anecdotal examples, some econometric evidence finds that policy makers systematically take corrective measures in response to rising debt levels. Using long-term U.S. data from 1916 to 1995, Bohn (1998) concludes that the primary surplus is an increasing function of the debt-GDP ratio, and the ratio is mean-reverting, after controlling for war-time spending and for cyclical fluctuations. Davig and Leeper (2005) estimate a regime switching rule for tax policy over the post-war period in the U.S. and find that policy swings between periods when taxes pursue a countercyclical objective and periods when they respond aggressively to debt. Davig (2005) uses a Markov-switching model to test the global sustainability of U.S. post-war budget; he finds that threats to long-run sustainability posed by expanding periods of discounted debt are mitigated by the expectation of returning to a regime where debt is repaid. This evidence underscores the empirical relevance of considering alternative fiscal adjustments to tax reductions.[3]

3. The Model

The model economy consists of a government and a large number of infinitely-lived, identical households and firms.

3.1. The private sector.

Each period a representative household chooses consumption, C_t, capital, K_t, hours worked, L_t, and one-period government bonds, B_t, to maximize expected utility, given by

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\gamma} - 1}{1-\gamma} + \chi \frac{(1-L_t)^{1-\theta} - 1}{1-\theta} \right],$$

[3]Empirical work in the style of Bohn's suffers from a potential identification problem. Intertemporal government budget balance ensures that in any equilibrium there is a positive relationship between the value of debt and future net-of-interest surpluses. It is difficult to distinguish whether regressions of surpluses against debt represent the rule governing the fiscal authority's behavior or merely reflect a correlation that is a necessary implication of equilibrium. Markov switching estimates can be immune to this identification problem.

subject to the budget constraint

$$C_t + K_t + B_t = \left(1 - \tau_t^K\right) r_t K_{t-1} + \left(1 - \tau_t^L\right) W_t L_t + (1 - \delta) K_{t-1} + B_{t-1} R_{t-1} + T_t.$$

E_t is the expectation operator conditional on the household's information set at t, which contains all variables dated t and earlier. β is the discount factor ($0 < \beta < 1$). γ and θ are the inverses of elasticities of intertemporal substitution of consumption and leisure ($\gamma > 0$ and $\theta \geq 0$). τ_t^K and τ_t^L are proportional tax rates levied on capital and labor income. T_t is lump-sum transfers if positive (taxes if negative). δ is the capital depreciation rate ($0 \leq \delta \leq 1$). W_t is real wage and r_t is the capital rental rate.

A representative firm rents capital and labor to maximize profit

$$AK_{t-1}^{\alpha} \left(h^t L_t\right)^{1-\alpha} - W_t L_t - r_t K_{t-1},$$

where A is total factor productivity ($A > 0$), h is the constant growth rate of labor augmenting technology ($h \geq 1$), and α is the share of capital in output ($0 < \alpha < 1$). The total goods produced each period is $Y_t = AK_{t-1}^{\alpha} \left(h^t L_t\right)^{1-\alpha}$.

3.2. **The government.** To study the implications of alternative financing schemes for tax rate reductions, we posit simple rules for policy instruments that make choices of policy variables respond to the state of government indebtedness, as indicated by the debt-output ratio. The fiscal rules are:

$$\ln\left(\frac{\tau_{t+1}^K}{\tau^K}\right) = q_K \ln\left(\frac{s_t^B}{s^B}\right) + \xi_{t+1}^K, \qquad q_K \geq 0, \tag{1}$$

$$\ln\left(\frac{\tau_{t+1}^L}{\tau^L}\right) = q_L \ln\left(\frac{s_t^B}{s^B}\right) + \xi_{t+1}^L, \qquad q_L \geq 0, \tag{2}$$

$$\ln\left(\frac{s_{t+1}^T}{s^T}\right) = q_T \ln\left(\frac{s_t^B}{s^B}\right), \qquad q_T \leq 0, \tag{3}$$

$$\ln\left(\frac{s_{t+1}^G}{s^G}\right) = q_G \ln\left(\frac{s_t^B}{s^B}\right), \qquad q_G \leq 0, \tag{4}$$

where $s_t^B \equiv \frac{B_t}{hY_t}$, $s_t^T \equiv \frac{T_t}{Y_t}$, $s_t^G \equiv \frac{G_t}{Y_t}$. Variables without time subscripts are deterministic steady-state values. To allow for possibly permanent surprise changes in tax rates, we assume the tax disturbances are autoregressive

$$\xi_{t+1}^K = \rho_K \xi_t^K + \varepsilon_{t+1}^K \tag{5}$$

$$\xi_{t+1}^L = \rho_L \xi_t^L + \varepsilon_{t+1}^L \tag{6}$$

where $|\rho_K|, |\rho_L| \leq 1$, and ε_t^K and ε_t^L are *i.i.d.* shocks. Permanent tax changes set $\rho_K = \rho_L = 1$.

We refer to the q's in rules (1)-(4) as the "fiscal adjustment parameters." Sign restrictions on q_K, q_L, and q_G, summarized in table 1, are straightforward. When the debt-output ratio is above steady state, one of the future distorting tax rates is raised or the government consumption-output ratio is lowered to maintain fiscal solvency. As for q_T, because the model is calibrated to include transfers (instead of lump-sum taxes) in steady state, future transfers as a share of output must be lowered when the debt-output ratio rises. To isolate the impacts of alternative financing schemes, only one of the four fiscal rules is operative in each experiment. That is, in each policy experiment, only one of the four fiscal adjustment parameters is non-zero, as shown in table 1.

Policy choices must satisfy rules (1)-(4) and the government's budget constraint at each date:

$$B_t = G_t + R_{t-1}B_{t-1} - \tau_t^L W_t L_t - \tau_t^K r_t K_{t-1} + T_t. \tag{7}$$

3.3. **The solution method.** Following King, Plosser, and Rebelo (1988), the model, which has a deterministic growth trend h, is scaled by the factor of h^t. This creates a new discount factor, $\beta^* \equiv \beta h^{1-\gamma}$, such that the steady state of the economy has constant output growth and consumption, and investment are constant shares of output. An analytical solution is not available; the equilibrium conditions are log-linearized around the original steady state and analyzed in terms of percentage deviations from the economy's steady state growth path. The model is solved using Sims's (2001) algorithm.

We examine permanent tax cuts. The use of log-linearization may raise concerns about the quality of the first-order approximation when the equilibrium is away from the original steady state. Such concerns are alleviated by the facts that the equilibrium system for the model is nearly log-linear and that the size of tax cuts considered here is fairly small (a reduction of 1 percent of tax rates from their original steady state levels). To check the quality of the approximation, we compare consumption, investment, labor, and output in the new steady state (the steady state to which the economy evolves after a permanent 1 percent cut in tax rates) solved by two methods: one uses approximated log-linear equilibrium system and the other uses the non-linear equilibrium equations. The second method, solved numerically, yields accurate results for the new steady state. The comparison shows that the approximation errors for the four variables using the log-linearized system are all within 0.035 percent of their new steady state values.

3.4. **The equilibrium.** The unique competitive equilibrium consists of agents' decisions $\{C_t, L_t, K_t, B_t\}_{t=0}^{\infty}$, the firms' decisions $\{L_t, K_t\}_{t=0}^{\infty}$, prices $\{r_t, W_t\}_{t=0}^{\infty}$, and policy variables $\{B_t, G_t, \tau_t^L, \tau_t^K, T_t\}$ such that, given initial levels of capital and debt, K_{-1} and B_{-1}, in each period the optimality conditions for agents' and firms' problems are satisfied; the goods, capital, labor, and bond markets clear; the transversality conditions for capital and debt hold; the government budget constraint and the policy rules (equations (1)-(4)) are satisfied.

Existence and uniqueness of an equilibrium depend crucially on the size of the fiscal adjustment parameters. Only certain ranges of these coefficients ensure that expected government debt does not grow faster than the economy, so the transversality condition for debt, $E_t \lim_{T\to\infty} \beta^{t+T-1} u'(c_{t+T}) \frac{B_{t+T}}{h^{t+T+1}} = 0$, is satisfied. In general, when a future fiscal variable is under- or over-adjusted (the absolute value of the corresponding non-zero q is either too small or too large), an equilibrium fails to exist. It is easy to see why under-adjustment does not produce an equilibrium: government expenses are not reduced or receipts do not grow sufficiently to rein in the speed of debt growth relative to output. When future policy is over-adjusted, the reasons an equilibrium fails to exist vary, depending on which fiscal variable responds to the debt. If the government spending share or one of the two tax rates responds, then lowering the spending share or raising a tax rate too much could slow down output more than the reduction in debt, and the debt-output ratio still rises and fails to converge to a constant level. If the transfer share responds, reducing this share too much can produce negative government debt (government lends to the private sector). Policy rule (3) becomes meaningless as $\ln\left(s_t^B/s^B\right)$ is undefined when $s_t^B/s^B < 0$. The analysis here focuses on the ranges of the non-zero q's that yield a unique equilibrium.[4]

3.5. **Model calibration.** The model is calibrated at an annual frequency. Table 2 reports the benchmark values of parameters and some steady state variables before a permanent tax rate change. The choice of the structural parameters is comparable to those in similar models with distorting capital and labor income taxation [Braun (1994), McGrattan (1994), Jones (2002), and Yang (2005)]. The model implies that in the original steady state, the fraction of time spent working is 0.20, the consumption-output ratio is 0.63, the investment-output ratio is 0.17, and the debt-output ratio is about 0.4. Each q value represents how aggressively the specified policy responds to government debt. For example, if the transfer share is adjusted, under the benchmark parameter setting, $q_T = -0.4$ and $q_G = q_K = q_L = 0$. The benchmark settings of q's are chosen so that the adjustment of future fiscal variables is as gradual as it can be to maintain a sustainable budget, while ensuring the economy evolves to a new steady state after about 100 years.[5]

[4]Our rationale for restricting attention to equilibria with non-negative government debt is that in practice governments are rarely net lenders to the private sector.

4. Dynamic Impacts of Permanent Tax Rate Cuts

This section reports the dynamic impacts of permanent reductions in capital and labor tax rates and shows how those impacts change when the financing schemes vary among permanently higher lump-sum taxes, a lower government consumption-output ratio, and increases in other proportional tax rates.

4.1. **Tax-rate cuts financed by lump-sum taxes.** To show that the government financing rule is an important determinant of the growth effects of permanent tax cuts, first we examine the consequences of tax rate cuts financed by lump-sum taxes. The policy rule for the transfer-output share, (3), is operative, with $q_T = -0.4$, so debt-financed deficits reduce expected future transfers (raise lump-sum taxes). Figure 1 reports the responses to a permanent 1 percent cut in the capital or labor tax rate, financed by sales of government debt under the parameter values in table 2.[6] The solid lines are the responses to a capital tax rate cut, and the dashed-dotted lines are those for a labor tax rate cut.

Both cuts in capital and labor taxes generate growth, with higher investment and hours worked along the transition path. In the short run, substitution effects created by lower capital and labor tax rates entice agents to invest more and work harder, raising output. As the economy converges to the new steady state, wealth effects from higher disposable income raise consumption and leisure; investment and hours worked subside somewhat, but remain above their original steady state levels. While the model used here is discrete and stochastic and the one in Mankiw and Weinzierl (forthcoming) is continuous and deterministic, the qualitative patterns for permanent capital or labor tax cuts are the same across the two models. Revenues from capital and labor income taxes are permanently lower (bottom right panel) and the shortfall is absorbed by permanently higher lump-sum taxes (bottom left panel).

When the government has access to a non-distorting tax instrument, lower tax rates appear to be powerful stimulants to growth. We now consider the growth effects when policy must adjust government consumption or distorting taxes to ensure fiscal sustainability.

4.2. **Alternative financing schemes.** We consider the consequences of permanent reductions in capital (or labor) tax rates, which are financed initially by government

[5] Section 5 considers the implications of varying the settings of the q's.

[6] Although Mankiw and Weinzierl (forthcoming) finance these tax-rate reductions with contemporaneous lump-sum taxes, rather than debt, Ricardian equivalence ensures the two exercises produces identical results in this model.

debt and eventually by permanent reductions in government consumption or permanent increases in labor (or capital) tax rates. Figure 2 plots the dynamic responses of macroeconomic variables to a permanent, unexpected 1 percent cut in the capital tax rate at time 0. Dashed-dotted lines are the impacts with $q_G = -0.2$ and $q_T = q_K = q_L = 0$; solid lines are the impacts with $q_L = 0.2$ and $q_G = q_T = q_K = 0$; for reference, we repeat the responses from figure 1, which are dashed lines obtained when $q_T = -0.4$ and $q_G = q_K = q_L = 0$.[7]

When the capital tax rate is permanently cut, it increases the expected rate of return to investment. Regardless of which policy rule is used, agents sacrifice consumption in order to invest more in the first few years; consumption initially falls below the level in the original steady state path. Lower consumption raises the marginal utility of consumption, raising the marginal benefit of working and the supply of labor. Higher labor and higher capital stock produce more output. After a few years, the wealth effects of higher income raise consumption and keep investment above its original steady state path.

On the government financing side, the capital tax rate cut drives up the government debt-output ratio. When lump-sum taxes rise with debt, the tax reduction has its largest positive effects on investment, hours, and output (dashed lines). This outcome is not surprising, as a distorting source of tax revenues is replaced by a non-distorting source.

Alternative financing schemes, however, involve changing some other distortion, with important implications for the impacts of tax changes. Reductions in the government consumption-output ratio (dotted-dashed lines) raise wealth as the government absorbs a smaller share of output. Wealthier households consume more leisure, reducing hours worked both along the transition path and in the new steady state. In the long run, the reduction in the government consumption ratio crowds in private consumption, raising consumption above its original steady state level. Ultimately, a higher after-tax return on investment raises the steady state capital stock and output, though by less than when lump-sum taxes adjust to clear the government budget.

When the labor income tax rate rises to compensate for the lower capital tax rate, the permanently lower after-tax return to labor reduces hours worked in the new steady state. After rising initially, output declines back to its original steady state level. Permanently higher investment, coupled with a fixed government consumption-output ratio, implies that consumption is lower in the new steady state.

[7]We do not allow a tax rate to adjust in response to its own shock. This simply allows the tax rate being shocked to be permanently held at 1 percent below its original steady state level.

The bottom right panel of the figure shows that total revenues derived from capital and labor income taxes are permanently lower when government consumption or lump-sum taxes adjust, while revenues rise when labor tax rates adjust. The permanently higher revenues following a capital tax cut arise from higher future labor tax rates. It would be misleading to infer that capital tax cuts *per se* generate permanently higher revenues.

Analogous, but different, patterns of results emerge when a permanent labor tax rate reduction is financed by three alternative schemes. Figure 3 reports responses to a 1 percent labor tax rate cut. Dashed-dotted lines and dashed lines report effects when government consumption and lump-sum taxes adjust using the same parameter settings that underlie figure 2. Solid lines give the responses when capital taxes adjust with $q_K = 0.3$ and $q_T = q_G = q_L = 0$.

Once again, the tax impacts on investment, hours worked, and output are largest when lump-sum taxes respond to debt to satisfy the government budget constraint. Permanently lower labor tax rates raise the return to labor and increase equilibrium hours and output for the first few years. The deficit-financed tax cut raises debt as a share of output.

When future government consumption is reduced in response to the rising debt, the positive wealth effect offsets the substitution effect induced by a higher after-tax real wage, and within 15 years of the tax cut, hours worked fall as the economy converges to a new steady state with lower employment, output, and investment. This negative long-run growth outcome is strikingly different from the case when lump-sum transfers are used to respond to higher debt. As before, the reduced steady state government share crowds in private consumption.

If higher debt raises expected capital taxes, the long-run negative growth effects are still more pronounced. Lower expected returns to investment sharply reduce investment, output, and consumption.[8] After an initial increase, hours worked return rapidly to their original steady state level. When capital taxes are expected to adjust to balance the budget, a permanent cut in labor taxes produces only an ephemeral increase in growth; in the long run, growth can fall.

Fiscal adjustments operating through government consumption or one of the two distorting income taxes can generate permanent changes in important macroeconomic variables. This result is an outgrowth of the permanent increase in the debt-output ratio induced by the permanent tax cuts. A higher level of government indebtedness carries with higher debt service, which requires permanent fiscal adjustments to ensure the government is solvent.

[8]Similar results appear in Gordon and Leeper's (2005) study of countercyclical fiscal policies.

5. Debt-Output Ratio and Growth Effects of Tax Cuts

We have shown, perhaps not surprisingly, that the dynamic impacts of tax-rate reductions hinge critically on assumptions about which fiscal instruments adjust to satisfy the government's budget constraint intertemporally. What might be surprising is that even in a bare-bones neoclassical growth model, the speed of fiscal adjustment can matter.

Figures 4 and 5 reproduce the exercises in figures 2 and 3 under a variety of settings of the fiscal adjustment parameters (the q's). Those parameters take values that imply the adjustment ranges from gradual, as in figures 2 and 3, to aggressive. Figure 4 shows results for a permanent capital tax rate cut. In the first column, government consumption adjusts, with $q_G = -0.2$ (dotted-dashed line), $q_G = -0.3$ (dashed line), and $q_G = -0.9$ (solid line). Column two varies the response of transfers to debt, with $q_T = -0.3$ (dotted-dashed), $q_T = -0.5$ (dashed), and $q_T = -1.5$ (solid). In the last column, the labor tax rate adjusts with settings of $q_L = 0.15$ (dotted-dashed), $q_L = 0.3$ (dashed), and $q_L = 0.8$ (solid). Figure 5 reports responses to a permanent labor tax rate cut. Columns one and two are generated under the same fiscal adjustment parameters as in figure 4; in the third column, the capital tax rate adjusts at speeds given by $q_K = 0.2$ (dotted-dashed), $q_K = 0.6$ (dashed), and $q_K = 2$ (solid). The choice of settings for the q's is somewhat arbitrary; they roughly cover the range of q's that yield a unique equilibrium. Different q values yield different quantitative results, but the qualitative patterns are covered by the values considered.

Several observations emerge from these figures. First, the aggressiveness of fiscal policy's response to debt matters a great deal for long-run growth effects (except, of course, when the transfer share adjusts). Second, the stronger the response to debt, the smaller the debt-output ratio in the new steady state, and the stronger the long-run growth effects of a tax cut (except when transfers adjust). For example, in response to a labor tax rate cut, when the government consumption ratio is the offsetting policy, the growth effects remain positive in the new steady state when $q_G = -0.9$. With $q_G = -0.3$, in contrast, the tax cut has essentially no growth effects, while $q_G = -0.2$ produces negative growth (column 1 of figure 5). In the case when capital taxes adjust to a labor tax rate cut, although long-run growth is negative under the three q_K's examined, the larger the q_K, the smaller the reduction in growth.

These figures put a sharp point on an earlier observation. The more rapidly policy adjusts to a tax cut, the less debt accumulates, and the lower is the required debt service. The level of debt service in the new steady state is an important determinant of long-run growth when debt must be serviced by a distorting fiscal instrument.

The systematic relationship between the speed of fiscal adjustment to debt and long-run growth outcomes has important policy implications. Not only does tax policy influence long-run growth, but debt management policy also matters. A relatively small response in the short run when the budget starts deteriorating can be more costly in terms of growth in the long run.

6. Revenue Effects of Tax Cuts

A major concern of fiscal authorities is how the growth effects of tax policies affect the revenue estimates of tax proposals. A tax proposal estimated to have smaller revenue loss is more likely to be adopted than one with bigger losses. Under the presumption that tax cuts generate growth, revenue estimation by either static scoring or the methods conventionally used by government agencies overlooks the growth effects of tax cuts, and hence overstates their associated revenue losses.

Mankiw and Weinzierl's (forthcoming) calculation in a model without debt supports this claim. Under their benchmark parameter values, they find that growth pays for 53 percent of the static revenue loss in the new steady state for a capital tax rate cut, and 17 percent for a labor tax cut. Also, the revenue loss for either tax cut is smaller than the static revenue loss in each period along the transition path. This result is expected, as tax cuts financed by reducing lump-sum transfers generate higher output both on the transition path and in the new steady state. Table 3 calculates the percentage of static revenue effects offset by higher growth at various points in time using the setup where lump-sum transfers adjust to clear the budget. Tax revenue is defined as the sum of capital and labor taxes and does not include lump-sum taxes. Static revenue effects are computed holding the tax base at its original steady state path (as if the tax cuts have no impact on tax bases). Under our benchmark parameter values, 95.2 percent and 47.2 percent of static revenue losses are offset by higher growth in the new steady state. As Mankiw and Weinzierl find, static scoring always overstates the revenue loss for tax cuts financed by lump-sum taxes or transfers.

Because the large revenue responses are driven by positive output reactions throughout the transition path, it is not difficult to see that if output turns negative, as it does when government consumption or capital taxes adjust to a permanent cut in the labor tax rate, static scoring can understate or overstate revenue losses. For example, when the future government consumption ratio is reduced in response to rising debt, under the benchmark parameter values, static scoring understates the revenue loss of a labor tax rate cut in the new steady state. Table 4 reports percentages of static revenue losses offset by higher growth when tax cuts are financed by reductions in the government consumption ratio. For a capital tax rate cut, 34.9 percent of static revenue loss is offset by higher growth in the new steady state. In the case of a labor tax rate cut, the revenue loss under dynamic scoring is 13 percent above the loss under static scoring in the new steady state. In other words, the conclusion that static revenue estimates always overstate the revenue loss of a tax cut, as Mankiw and Weinzierl (forthcoming) argue, may not hold when taxes are financed by schemes other than lump-sum transfers.

Differences between the dynamic scores we report in table 3 and Mankiw and Weinzierl's results stem from differences in model calibrations. The differences can be reconciled by changing three aspects of our calibration: reduce the steady state capital tax rate from .35 to .25; increase the steady state percentage of time spent working from 20 percent to 34 percent; reduce the intertemporal elasticity of substitution of leisure from 1 to .5. Under the alternative calibration, the degree to which permanent tax reductions are self-financing is much closer to Mankiw and Weinzierl's numbers: 66.8 percent for capital taxes and 25.3 percent for labor taxes in the new steady state.

We do not wish to argue that one set of numbers is more plausible than another. Our point is that the numbers are sensitive both to model calibration, as Mankiw and Weinzierl acknowledge, and to assumptions about how future policy responds to debt-financed tax cuts.

7. Concluding Remarks

Mankiw and Weinzierl (forthcoming) provide a provocative answer to the pressing policy issue of whether conventional theory is consistent with the popular view that tax cuts can be self-financing. Their optimistic conclusion is that, although not fully self-financing, permanent reductions in capital and labor taxes can stimulate economic growth and expand the tax base enough to offset sizeable fractions of the revenue losses. The thought experiment underlying this sanguine conclusion involves replacing a distorting tax with a non-distorting tax.

To be sure, Mankiw and Weinzierl have isolated one mechanism at work following tax changes. But implementing their thought experiment may be difficult in practice, as it entails reducing politically sensitive transfer programs to balance the government's budget intertemporally. In practice, reduction in one source of distortion may be associated with change in some other distortion. This paper has examined two other distortions—government consumption and an alternative tax rate—to find that Mankiw and Weinzierl's conclusions about the growth effects of tax reductions hinge on the particular thought experiment they conduct. Very different results emerge when other distortions adjust.

The paper has also shown that how aggressively policies adjust to increases in government debt can matter for the long-run growth effects of tax reductions. Postponing adjustment or very gradual adjustment can take the economy to a new steady state with higher debt. When that debt is serviced with a distorting fiscal instrument, the beneficial growth effects of tax reductions can be partially or completely reversed.

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	s^T_{t+1} adjusts	s^G_{t+1} adjust	τ^K_{t+1} adjusts	τ^L_{t+1} adjusts
q_T	<0	0	0	0
q_G	0	<0	0	0
q_K	0	0	>0	0
q_L	0	0	0	>0

TABLE 1. Parameter settings under various policy rules.

parameter	value	parameter	value	parameter	value	parameter	value
α	0.36	δ	0.1	s^T	0.07	q_K	0.3
β	0.96	h	1.02	τ^K	0.35	q_L	0.2
γ	1	χ	3	τ^L	0.25	q_T	-0.4
θ	1	s^G	0.2	q_G	-0.2	ρ_K, ρ_L	1

TABLE 2. Benchmark parameters settings.

years after a tax cut	capital tax rate cut	labor tax rate cut
on impact	44.5	36.2
1	54.3	38.3
3	68.8	41.5
5	78.1	43.5
10	89.4	46.0
25	94.9	47.2
new steady state	95.2	47.2

TABLE 3. Percent of static revenue impact offset by higher growth when tax cuts financed by lump-sum transfer-output ratio reductions.

years after a tax cut	capital tax rate cut	labor tax rate cut
on impact	38.1	30.0
5	53.7	20.1
10	53.5	11.2
20	46.1	-0.6
40	37.8	-9.9
60	35.6	-12.2
80	35.1	-12.8
new steady state	34.9	-13.0

TABLE 4. Percent of static revenue impact offset by higher growth when tax cuts financed by government consumption-output ratio reductions.

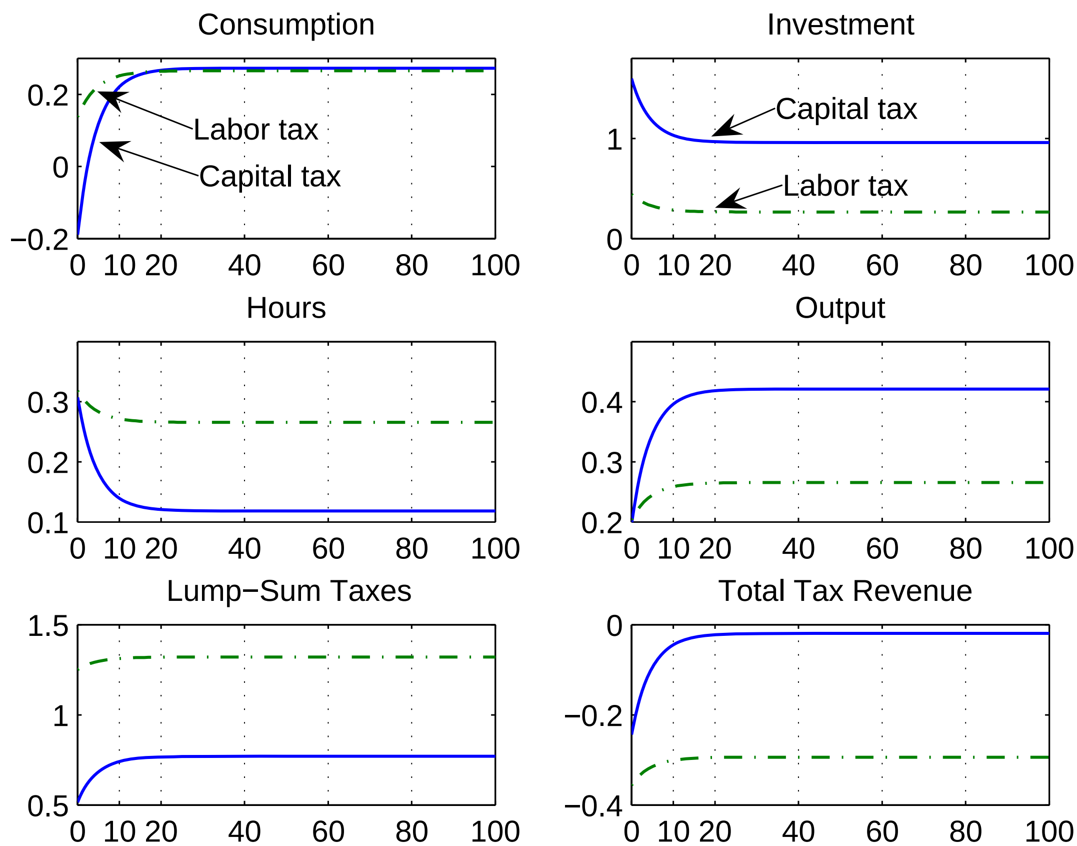

FIGURE 1. Impulse responses to a permanent 1% capital or labor tax rate reduction when lump-sum taxes adjust to balance the budget (in perecent). The surprise tax cut occurs at period 0. Responses plotted over 100-year horizon when economy has approximately reached new steady state path.

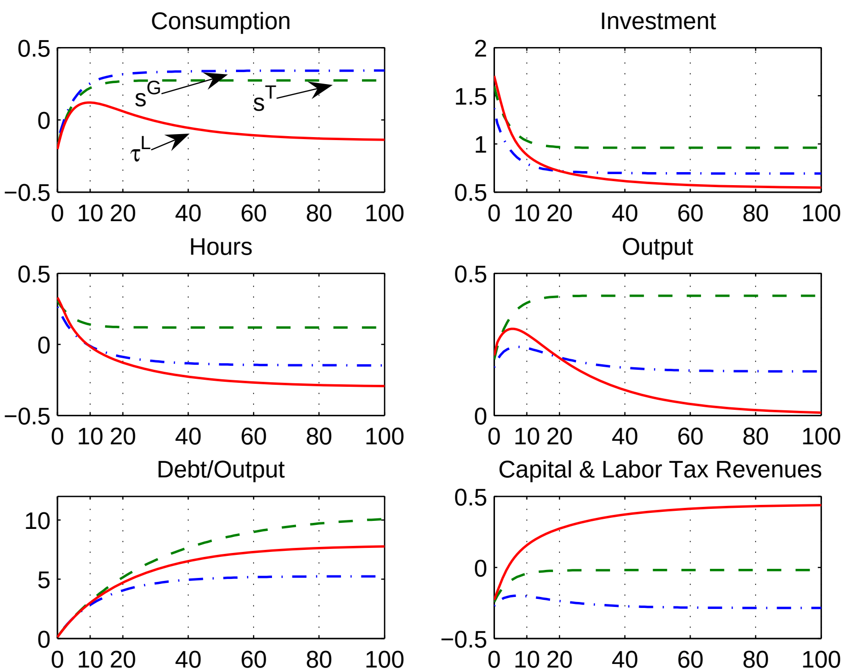

FIGURE 2. Alternative Financing Schemes. Responses to a permanent 1% capital tax rate reduction (in percent). The surprise tax cut occurs at period 0. Responses plotted over 100-year horizon when economy has approximately reached new steady state path. Government consumption adjusts in dotted-dashed line; labor tax rates adjust in solid line; lump-sum transfers adjust in dashed line.

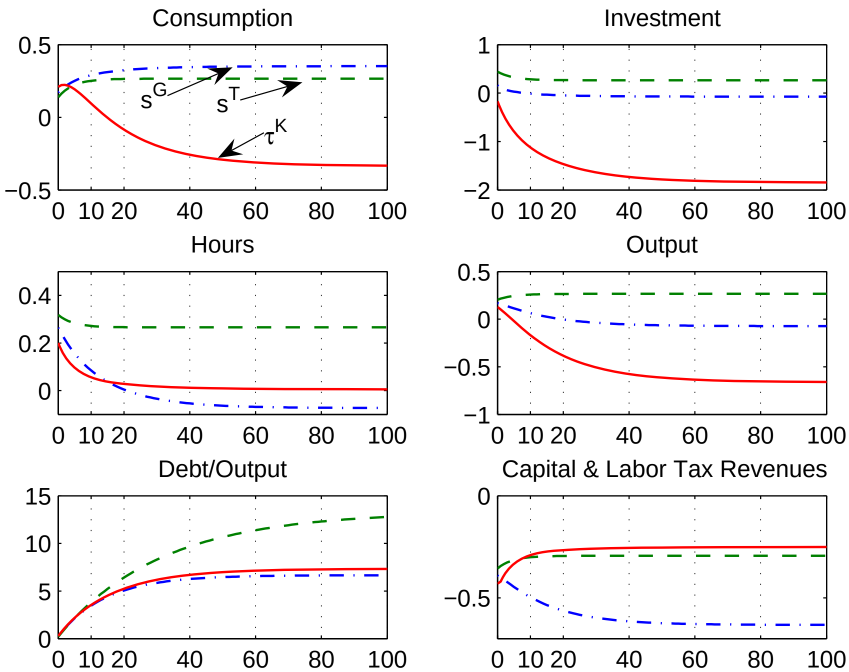

FIGURE 3. Alternative Financing Schemes. Responses to a permanent 1% labor tax rate reduction. The surprise tax cut occurs at period 0. Responses plotted over 100-year horizon when economy has approximately reached new steady state path. Government consumption adjusts in dotted-dashed line; capital tax rates adjust in solid line; lump-sum transfers adjust in dashed line.

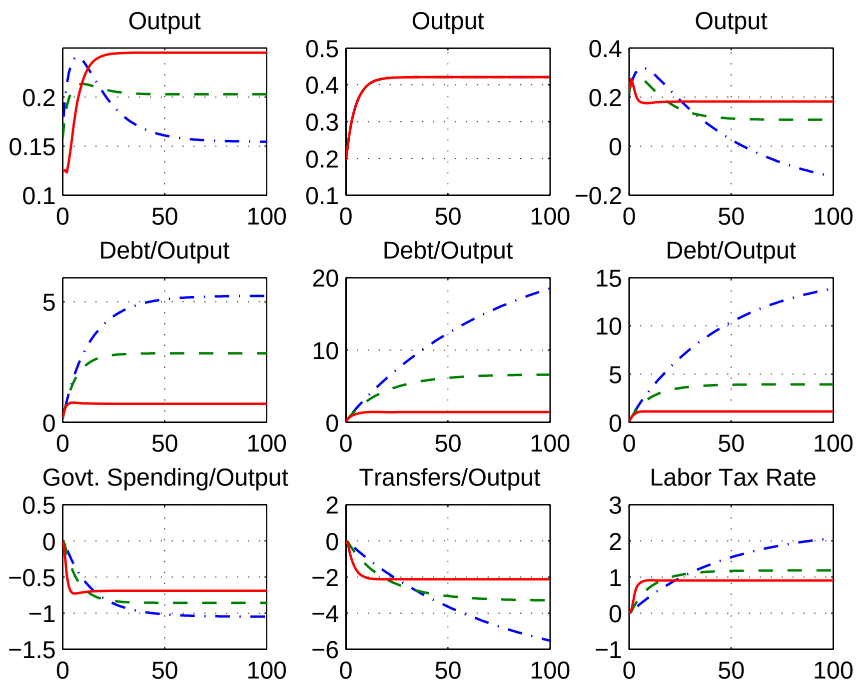

FIGURE 4. Various Fiscal Adjustments to a Permanent 1% Capital Tax Rate Reduction. The surprise tax cut occurs at period 0. Responses plotted over 100-year horizon when economy has approximately reached new steady state path (in percent). First column—government consumption adjusts: dotted-dashed ($q_G = -.2$), dashed ($q_G = -.3$), solid ($q_G = -.9$). Second column—transfers adjust: dotted-dashed ($q_T = -.3$), dashed ($q_T = -.5$), solid ($q_T = -1.5$). Third column—labor taxes adjust: dotted-dashed ($q_L = .15$), dashed ($q_L = .3$), solid ($q_L = .8$).

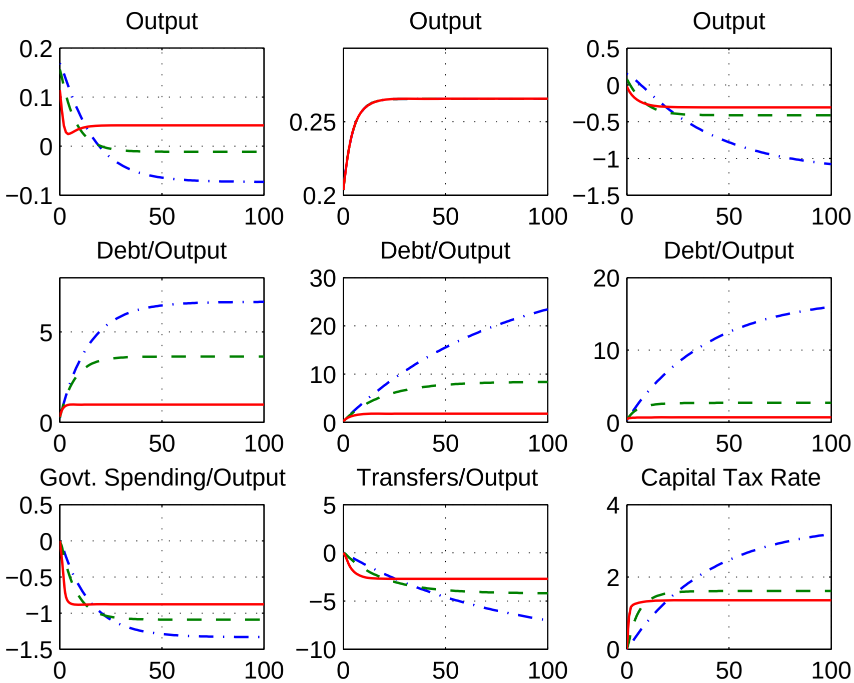

FIGURE 5. Various Fiscal Adjustments to a Permanent 1% Labor Tax Rate Reduction. The surprise tax cut occurs at period 0. Responses plotted over 100-year horizon when economy has approximately reached new steady state path (in percent). First column—government consumption adjusts: dotted-dashed ($q_G = -.2$), dashed ($q_G = -.3$), solid ($q_G = -.9$). Second column—transfers adjust: dotted-dashed ($q_T = -.3$), dashed ($q_T = -.5$), solid ($q_T = -1.5$). Third column—labor taxes adjust: dotted-dashed ($q_K = .2$), dashed ($q_K = .6$), solid ($q_K = 2$).